Low-Loss Millimeter-Wave Isolators for Cryogenic Systems, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

Ferrite based isolators are useful for controlling standing waves in a wide variety of millimeter-wave (MMW), and terahertz (THz) systems. A good example of their usefulness is found in high frequency local oscillator systems. These systems typically comprise a lower frequency oscillator driving a cascade of frequency multipliers. Standing waves arise due to impedance mismatches between the highly tuned components. This in turn gives rise to dips or even nulls in the output of the multiplier chain. The standing waves are often mitigated with complicated impedance matching techniques that are implemented on a case-by-case basis at a great cost in time and money. By using suitable isolators, the standing waves could be suppressed at a fraction of the time and cost.

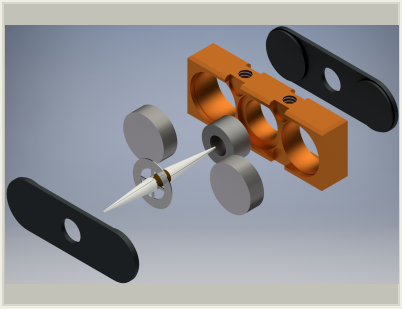
The high insertion loss of these components renders them unsuitable for use in most MMW systems. The typical insertion loss of a WR-6.5 isolator (110-170 GHz) is more than 3 dB. The problem is worse at higher bands. Micro Harmonics Corporation has recently developed a revolutionary new line of isolators with significantly reduced insertion loss. Our WR-8 and WR-6.5 isolators have a measured insertion loss of less than 1 dB over most of the waveguide band. By April of this year, a full line of low-loss isolators covering bands from WR-12 (60-90 GHz) through WR-3.4 (220-325 GHz) will be available.

Many NASA instruments are designed for use at cryogenic temperatures. However, cryogenically rated isolators are currently unavailable at frequencies above 40 GHz. Isolators designed for room temperature operation have poor isolation at cryogenic temperatures due to changes in the ferrite properties. The isolators must be fundamentally redesigned for cryogenic use. We propose to develop high-frequency isolators optimized for cryogenic temperatures that exhibit significantly reduced loss and improved isolation and bandwidth making them useful for many of the instruments now being developed for NASA missions.

Anticipated Benefits

Isolators are useful in a wide range of NASA systems including the heterodyne receivers used in Marvel, VESPER, MACO and SIRICE. They find potential application in the local oscillator (LO) chains for the high-resolution heterodyne array receivers at 1.9 THz used in the Stratospheric Observatory for Infrared Astronomy (SOFIA) and the Stratospheric Terahertz Observatory (STO-2) and the 4.7 THz multiplied local oscillator source for the observation of neutral oxygen.

Isolators are broadly used in scientific instruments for plasma diagnostics (ITER), chemical spectroscopy, biomaterial analysis, and radio astronomy. There are applications in military systems such as compact range radar, imaging systems, covert communications systems, and chemical and



Low-Loss Millimeter-Wave Isolators for Cryogenic Systems, Phase I

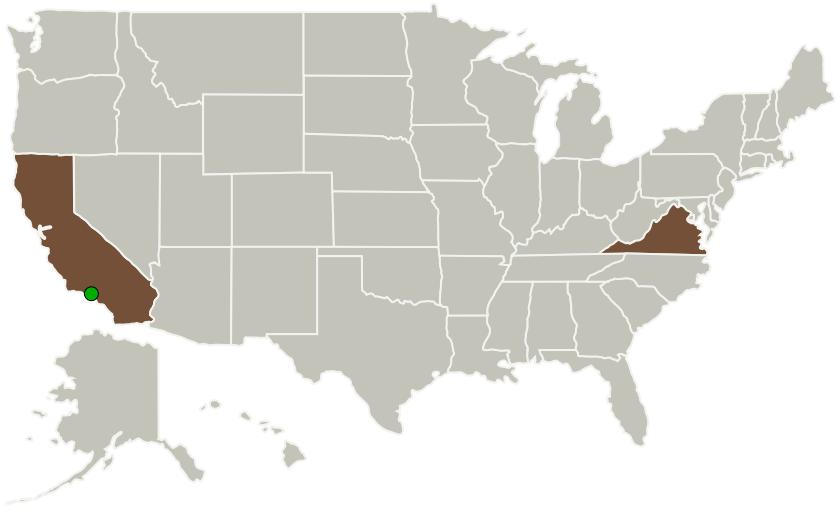
Table of Contents

Low-Loss Millimeter-Wave Isolators for Cryogenic Systems, Phase I

Completed Technology Project (2018 - 2019)

bio-agent detection systems. There are applications in biomedical systems for the real time analysis of skin diseases, portal security scanners, high frequency data links and industrial process control systems.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Micro Harmonics Corporation	Lead Organization	Industry	Fincastle, Virginia
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
California	Virginia

Project Transitions

July 2018: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Micro Harmonics Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

David W Porterfield

Co-Investigator:

David M Porterfield

Low-Loss Millimeter-Wave Isolators for Cryogenic Systems, Phase I

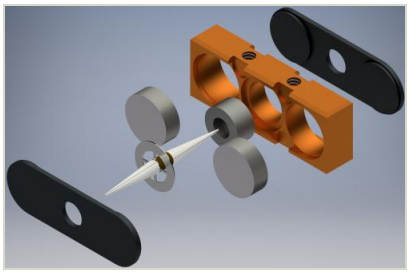
Completed Technology Project (2018 - 2019)

February 2019: Closed out

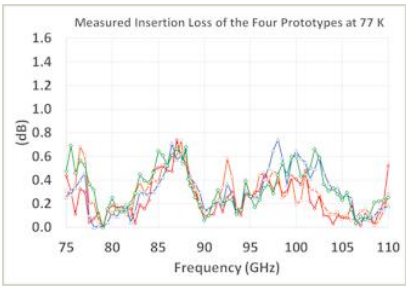
Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141165)*

Images



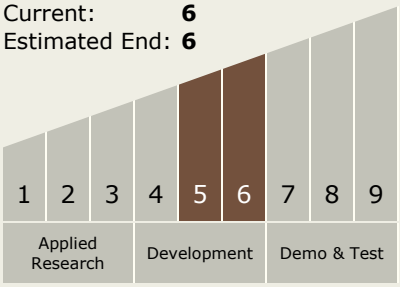
Briefing Chart Image
Low-Loss Millimeter-Wave Isolators for Cryogenic Systems, Phase I *(https://techport.nasa.gov/image/127332)*



Final Summary Chart Image
Low-Loss Millimeter-Wave Isolators for Cryogenic Systems, Phase I *(https://techport.nasa.gov/image/130847)*

Technology Maturity (TRL)

Start: **5**
Current: **6**
Estimated End: **6**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destinations

The Moon, Mars